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Conference Abstract

Future-Proofing Chocolate: The Environmental Resilience of Cacao Wild Relatives

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Abstract

Cacao (*Theobroma cacao* L.) is a globally important crop, forming the basis of the multi-billion-dollar chocolate industry and supporting livelihoods in tropical regions worldwide (Houston and Wyer 2012). Cacao is highly sensitive to drought stress, a significant threat to plant growth and survival, pod yield, and bean quality (Mensah et al. 2023). Periods of water deficit can cause yield losses up to 50%, likely worsening with climate change-induced increases in drought frequency and intensity (Gateau-Rey et al. 2018).

Theobroma cacao is a member of *Theobromateae*, a tribe in the Malvaceae family with 40 species in three genera known collectively as cacao wild relatives (CWRs). It is likely that some CWRs are adapted to drought and may provide valuable genetic material suitable for "future proofing" chocolate production against climate change (Medina and Laliberte 2017). While there have been low success rates for cross-breeding *Theobroma* species, recent advances in plant molecular biology are making the use of CWRs in crop breeding programs much more viable (Bohra et al. 2022).

This project has two aims:

1. Develop a database of occurrence records of all CWRs and use this to produce Species Distribution Models (SDMs). The SDMs will provide data on the climatic

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tolerance of each CWR and indicate which of them are likely sources of drought tolerance genes/traits.

2. Assessing the conservation status of CWRs is crucial in order to protect this natural bank of potentially useful genetic resources. We will predict the CWR range changes under various climate and land-use scenarios to determine their conservation status.

Distribution data have been collated from taxonomic treatments (Cuatrecasas 1964, Schultes 1958, Colli-Silva in prep.), large and globally important herbaria (e.g., Herbaria Nacional Colombiano (COL), The New York Botanical Garden (NY)) and Latin American herbaria (e.g., Instituto Nacional de Pesquisas Amazonia (INPA), Pontificia Universidad Católica del Ecuador (QCA), abbreviations follow Thiers (2001)).

Specimens will be taxonomically verified with reference to the taxonomic literature, georeferenced to within 5 km (Hackeloeer et al. 2014) and cleaned through automatic (Zizka et al. 2019) and manual plotting in geographic space to check for outliers. Spatial biases will be minimized using spatial filtering (Kramer-Schadt et al. 2013).

We will use three SDM methodologies, all fit with data from freely available global datasets (Karger et al. 2017):

- MaxEnt, the most commonly used SDM methodology;
- one of the recently developed trait-based SDMs designed to incorporate prior knowledge about trade-offs and plasticity in functional traits, minimising the risk of model over-prediction (Benito Garzón et al. 2019);
- a novel, modified SDM methodology that accounts for CO_2 fertilisation in future predictions (Prentice et al. 2022).

These SDMs will estimate Predicted Niche Occupancy profiles (Heibl and Calenge 2018) that will

- characterise drought resistance of CWRs,
- test for associations with species' genes/traits.

To assess the conservation status of these CWRs, SDMs will be projected into future climate and emission scenarios, represented by the Intergovernmental Panel on Climate Change's Shared Socioeconomic Pathways, mediated by models of future land-use change. Species will be characterised by the overall change in their projected range sizes and the loss of their current range sizes. The results will be used to assess the conservation status of CWRs under International Union for Conservation of Nature criteria (IUCN 2012).

Keywords

species distributions, crop wild relatives, global change, drought tolerance, genetic resources, climate projections

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Conflicts of interest

The authors have declared that no competing interests exist.

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